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## Space Weather Technical Forecast

Issued on Monday, 04 April 2022 at 13:17 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

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**Space Weather Forecast Headline: Decreasing risk of Minor/Moderate radio blackouts. A geomagnetic storm (G1-G2) is likely on Day 3 (6th April) due to the arrival of a CME.**

### Analysis of Space Weather Activity over past 24 hours

**Solar Activity:** Solar activity has been Low over the past 24 hours. The largest flare of the period, originated from AR2976 in the northwest quadrant, near the western limb, peaking at C6.3 at 03/1309UTC. There are now five numbered sunspots on the visible disc, with the recent most active group, AR2975 now rotated over the western limb along with AR2984. In addition, AR2982 faded to plage in the eastern hemisphere. This has left the main frontside groups as AR2978, an Ehi/Beta, with minor intermediate spot development and spreading. All other groups were unipolar or decaying. AR2974 is about to rotate off disc.

There remains numerous large filaments on the disc. The most notable event of the last 24 hours was the lifting off of a large filament in the southwest quadrant, at 03/1600UTC. This event produced a coronal mass ejection (CME) which was observed in available coronagraph imagery and has been analysed. This shows an Earth-directed CME arriving sometime on Day 3 (6th April). No other Coronal Mass Ejections (CMEs) were visible in available imagery.

**Solar Wind / Geomagnetic Activity:** The solar wind, as measured by DSCOVR at L1, showed a gradual decline in many solar wind measures in the period, perhaps indicating an exit from negative polarity high speed stream influence and perhaps also residual CME effects. The solar wind started the period at slightly elevated levels, near 450km/s, before a sudden rise to elevated levels, with a peak of 531km/s at 03/1445UTC, before a gradual decline back to the slightly elevated levels, near 460km/s, by end of the period. The cause of this resurgence is uncertain, however the effect on geomagnetic activity was slight. Whilst the cause of this is uncertain, it may be a close pass from the 31 March M9.6 CME from AR2975, as this is indicated in MOSWOC Enlil as passing 1AU at this time, narrowly ahead of Earth in the track of its orbit.

The solar wind density was at background levels. IMF (bt) was generally weak, with a peak of 8nT and the all important north-south component (bz), ranging between +4 to -8nT. The phi angle was predominately negative (towards the sun), albeit with a step change evident to approach neutral after 03/1500UTC. The net result of the above solar wind measures was mainly Quiet (Kp1-2), with Unsettled (Kp3) intervals between 04/00-06UTC.

**Energetic Particles / Solar Radiation:** The high energy proton flux (10MeV) measured at GOES-16 showed a continuing gradual relaxation towards Background levels, having reached S1/Minor Storm on the 2nd April, in the wake of an M-class flare from the northwest limb.

The high energy (greater than 2MeV) electron flux as observed by GOES-16 at GEO showed an increased amplitude diurnal oscillation between Moderate and High flux, peaking at 2600pfu at 03/1505UTC. The 24-hour integrated fluence showed a steep rising trend followed by a gradual

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plateau, with  $9.4 \times 10^7$  integrated pfu recorded at 04/0001UTC.

## Four-Day Space Weather Forecast Summary

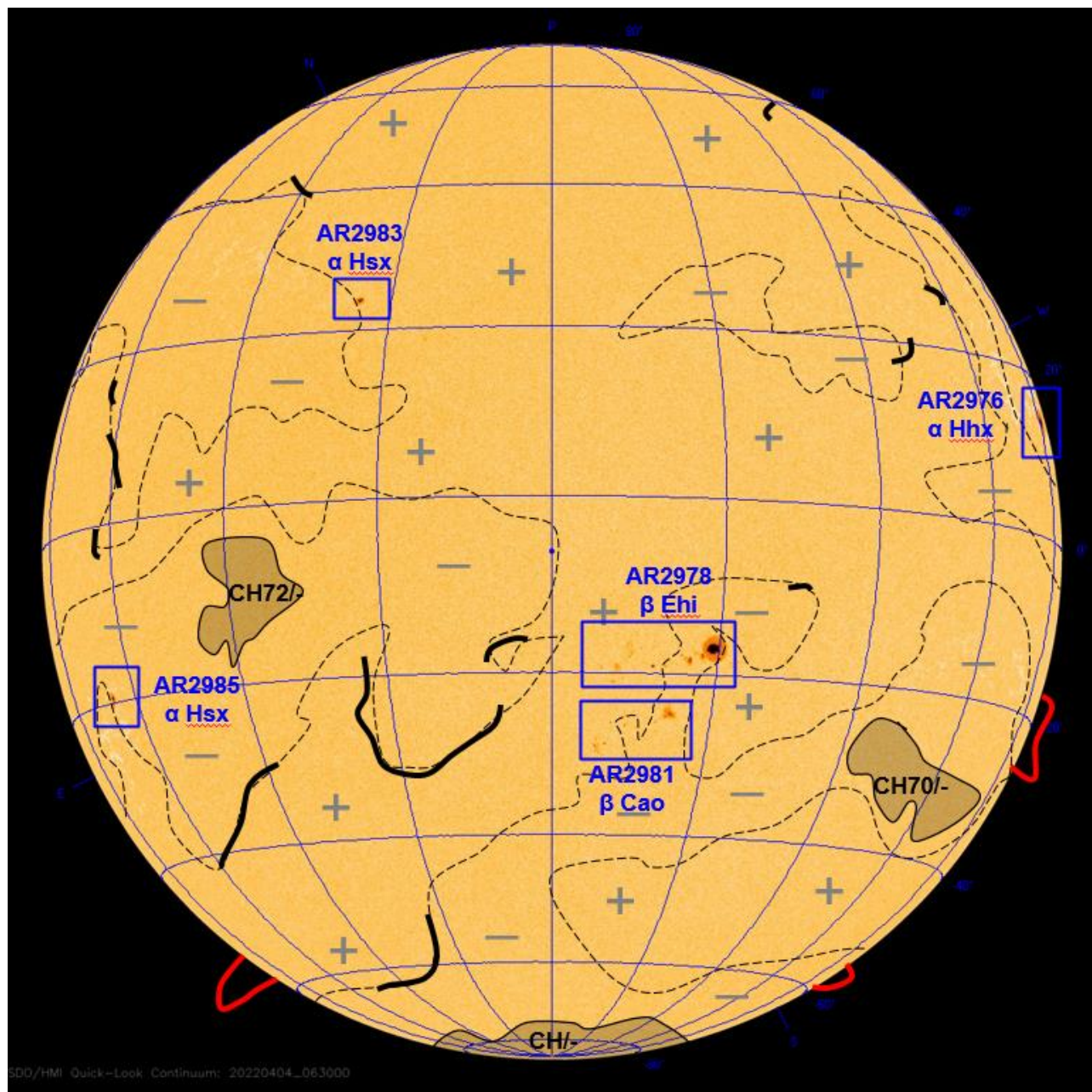
**Solar Activity:** The chances of further significant flares should continue to reduce, as sunspot regions in the northwestern quadrant leave the Earth-facing disc. Solar activity should be predominantly Low, with a much-reduced daily Chance of M-class flares.

**Solar Wind / Geomagnetic Activity:** An exit from the current fast wind is expected during Day 1 (4 April), with no further coronal holes forecast and mainly Quiet activity. The large filament eruption from the south centre disc on the 3rd April launched a CME, which has been analysed, and is Earth-directed, with an expected arrival sometime on Day 3 (6th April). This is likely to enhance geomagnetic activity, which will initially be Quiet, but increasing to Unsettled to Active, with a G1-G2/Minor/Moderate geomagnetic storm likely on Day 3 (6th April) and possibly into Day 4 (7th April). However, analysis of the 3rd April CME will undergo further analysis, so timings may be refined.

**Energetic Particles / Solar Radiation:** The risk of further solar radiation storms should now slowly reduce as the northwestern sunspot regions rotate off the disc.

The high energy (greater than 2 MeV) electron flux may show a slight day-on-day increase in the immediate term, in the wake of recent fast wind influence and now that residual CME activity has passed. Active fluence is Likely as a result, although this aspect is marginal. Flux levels may then be attenuated by the 03/1600UTC CME arrival, which is currently expected to arrive at Earth on Day 3 (6th April), with any recovery in fluence following this probably insufficient to breach Active.

Figure 1. Solar Analysis Valid 04/0630UTC.



**Key:** Filament \_\_\_, Prominence \_\_\_, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

**Geomagnetic Storms:**

Earth now appears to be undergoing a gradual exit from high speed stream influence, most likely that from CH70 or CH71 near the western limb. The solar wind speed is tracking close to levels seen on last rotation, and in this respect it should continue a gradual decline during the working week UTC, with mainly Quiet geomagnetic activity expected on Days 1 and 2 (4th and 5th April). However, there is an Earth-directed CME in the forecast, which left the sun on the 3rd April, as a result of a large filament eruption, observed lifting off the south-centre disc, around 03/1600UTC. This has been analysed and is likely to arrive at Earth sometime on Day 3 (6th April), although some uncertainty in the exact arrival time on the UTC day itself. Further analysis will need to be conducted to fine tune the forecast, although the date (6th April) for arrival of the CME appears to be good.

Geomagnetic activity is expected to predominately Quiet at the start of the period, before the arrival of the CME on Day 3 (6th April), with an enhancement in activity to Unsettled to Active, with a G1-G2/Minor-Moderate Storm likely on Day 3 (6th April) and possibly with activity lasting into Day 4 (7th April).

| Geo-Magnetic Storm       | Level    | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|--------------------------|----------|------------------------|-------------------|-------------------|-------------------|-------------------|
| Probability (Exceedance) |          |                        | (%)               | (%)               | (%)               | (%)               |
| Minor or Moderate        | G1 to G2 | No                     | 1                 | 5                 | 70                | 30                |
| Strong                   | G3       | No                     | 1                 | 1                 | 10                | 5                 |
| Severe                   | G4       | No                     | 1                 | 1                 | 1                 | 1                 |
| Extreme                  | G5       | No                     | 1                 | 1                 | 1                 | 1                 |

**Geomagnetic Activity - Earthbound Coronal Mass Ejections**

| Date/time 21.5R (UTC) | Halo: Full or Partial | Source            | Source Location    | Estimated Speed | Estimated Arrival Time | Comments                               |
|-----------------------|-----------------------|-------------------|--------------------|-----------------|------------------------|----------------------------------------|
| 03/04/2022 21:13      | Full                  | Filament eruption | Centre-SW quadrant | 595             | 06/1600UTC             | Reanalysis taking account of full halo |

Figure 2: STEREO-A (left) and LASCO (right) coronagraph images shows a full halo CME leaving the Sun (albeit rather faint in LASCO), after a filament eruption from the SW quadrant.

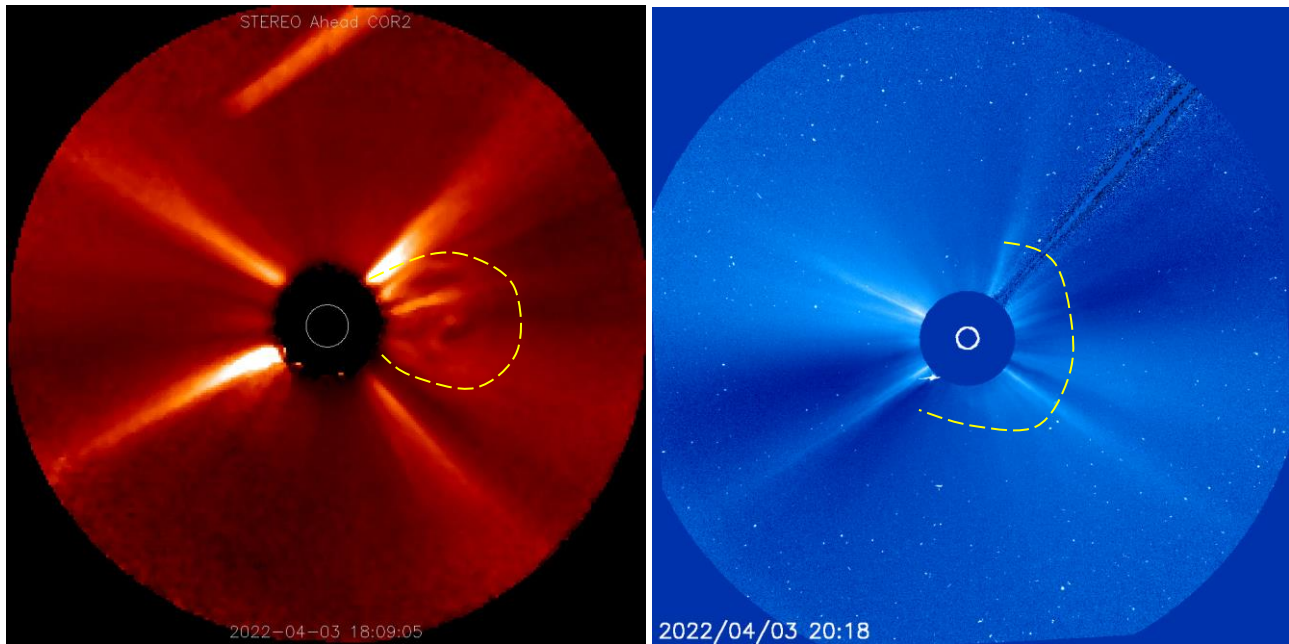
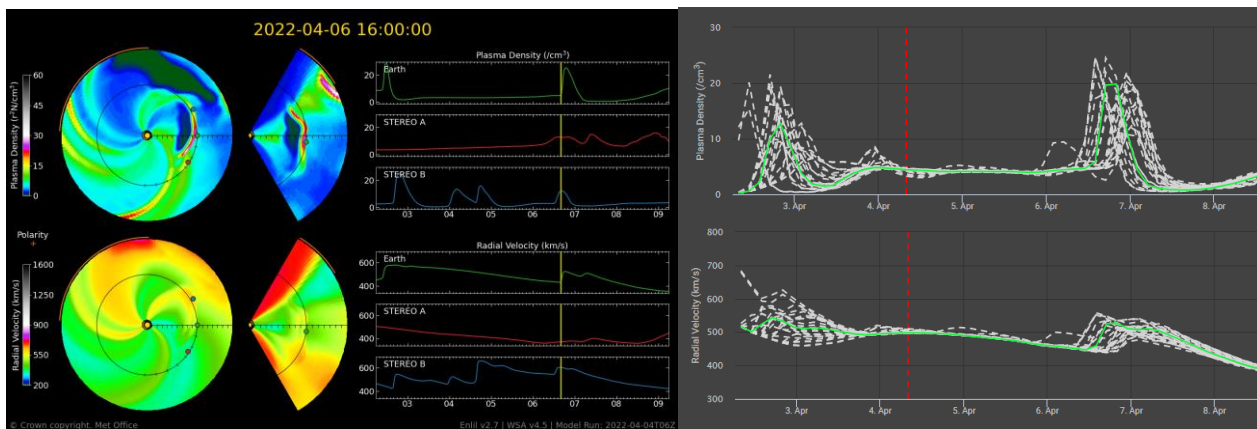


Figure 3: MOSWOC Enlil model (left) run showing the 03/1600UTC filament eruption arriving at Earth on Day 3 (6<sup>th</sup> April), probably late in the day. Ensembles (right) show a spread in expected arrival times, although the majority of the members are within the UTC day of the 6<sup>th</sup> April.



## Radio Blackouts - X-Ray Flares:

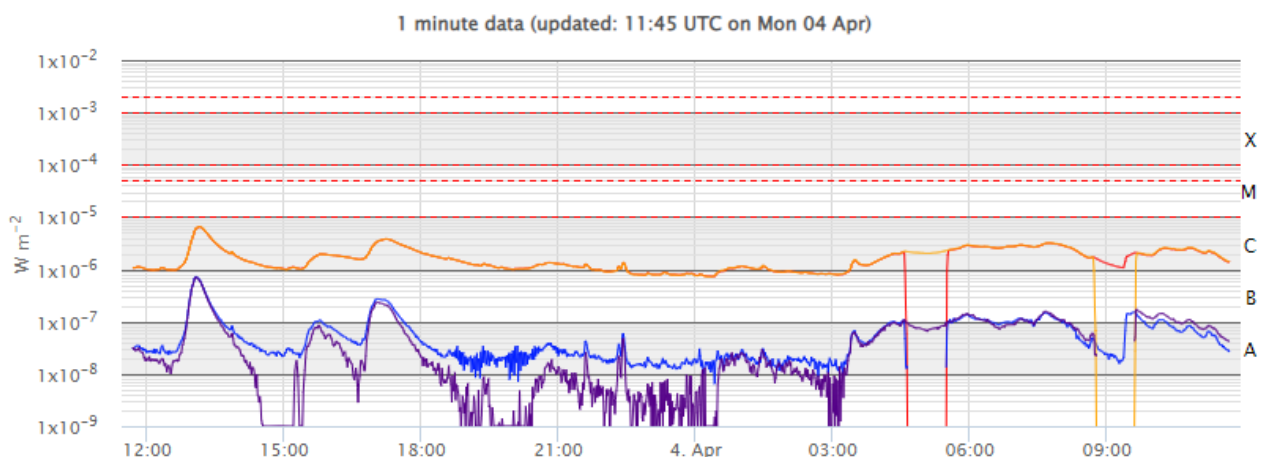
The sun now appears to show an overall waning in X-ray activity, particularly given the departure from the Earth-facing side of AR2975, the past week's most active spot by far. This should shortly be followed by AR2976, leaving unipolar groups and the fading AR2978 and AR2981 near centre disc.

There are numerous bright flux regions hinted at in STEREO A EUVI 195 imagery between 120 and 90E. These may offset the departing regions to some degree, however these will be analysed in due course and do not yet feature in the forecast.

Overall, the chances of significant X-ray flares should reduce in the coming four days, with the majority of this decrease occurring at the very start of the period. M-class flares are rated at a daily Chance throughout, largely the result of the raw potential of AR2978 and perhaps also AR2981, although this has not been borne out in their activity, and their growth phase appears to have stalled for the time being.

| X Ray Flares | Level               | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|--------------|---------------------|------------------------|-------------------|-------------------|-------------------|-------------------|
| Probability  |                     |                        | (%)               | (%)               | (%)               | (%)               |
| Active       | R1-R2<br>M Class    | No                     | 40                | 25                | 25                | 25                |
| Very Active  | R3 to R5<br>X Class | No                     | 5                 | 5                 | 5                 | 5                 |

**Figure 4: GOES16 X-Ray Flares – shows minor C-class flares occurring during the past 24 hours.**



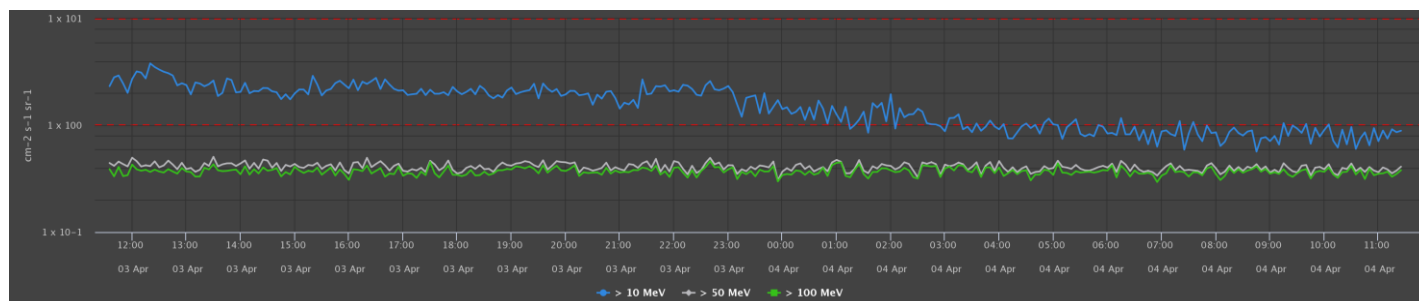
## Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) is now well below the S1/Minor Storm threshold but remains above normal background levels. This is expected to continue to decline back to normal background levels during the period.

The source of all the recent S1 and near-S1 level enhancements has now rotated around the northwest limb, and from here its contribution to the risk of further such events should begin to lessen, with AR2976 soon following. The residual risk of S1 should then be inherited by the westward advance of the large but relatively quiescent AR2978 and AR2981, perhaps offering a lower ongoing risk through midweek.

| Radiation Storms                                                                                                                                                    | Level<br>( $\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$ ) | Past 24 Hours<br>(Yes/No) | Day 1<br>(00-24 UTC) | Day 2<br>(00-24 UTC) | Day 3<br>(00-24 UTC) | Day 4<br>(00-24 UTC) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|---------------------------|----------------------|----------------------|----------------------|----------------------|
| Probability<br>(Exceedance)                                                                                                                                         |                                                            |                           | (%)                  | (%)                  | (%)                  | (%)                  |
| Active                                                                                                                                                              | $\geq \text{S1}$                                           | No                        | 15                   | 10                   | 10                   | 5                    |
| Very Active                                                                                                                                                         | $\geq \text{S3}$<br>*                                      | No                        | 1                    | 1                    | 1                    | 1                    |
| * $\text{S3} \geq 10 \text{ MeV} \geq 1000 \text{ pfu}$ and / or $\geq 50 \text{ MeV} \geq 10 \text{ pfu}$ . (pfu = $\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$ ) |                                                            |                           |                      |                      |                      |                      |

**Figure 5: GOES-16 Proton Flux** – shows a steady decline towards background levels, after recent S1 minor events due to large flares from AR2975, which has now rotated off the Earth-facing disc.



## High Energy Electrons Event ( $\geq 2\text{MeV}$ ):

High energy electron flux is likely to increase (at diurnal peak) during Days 1 and 2 (4th and 5th April) due to the waning effects of the recent high speed stream from coronal hole(s) influences, before reducing again, due to possible CME effects Days 3 and 4 (6th and 7th April). However, the chances of breaching 24-hour integrated Active fluence are near even, perhaps slightly more likely than not. The forecast confidence then drops significantly given the presence of a CME in the forecast, with this most likely to attenuate counts from midweek UTC, with any recovery following this probably insufficient to result in any further Active levels.

| GEO Electron Environment | Level ( $\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$ ) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|--------------------------|-----------------------------------------------------------|------------------------|-------------------|-------------------|-------------------|-------------------|
| Probability (Exceedance) |                                                           |                        | (%)               | (%)               | (%)               | (%)               |
| Active                   | $\geq 2 \text{ MeV}$<br>$\geq 1 \times 10^8$              | No                     | 60                | 60                | 40                | 20                |
| Very Active              | $\geq 2 \text{ MeV}$<br>$\geq 1 \times 10^9$              | No                     | 1                 | 1                 | 1                 | 1                 |

**Figure 6: GOES-16 Electron Flux** – shows a steady decline in activity due to the waning effects of a recent high speed stream from a coronal hole(s) influence.

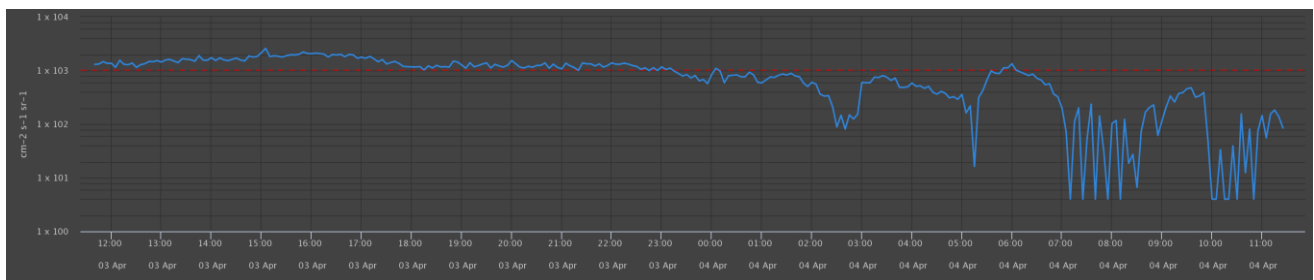


**Figure 7: REFM Electron Fluence** – observations and forecast.

